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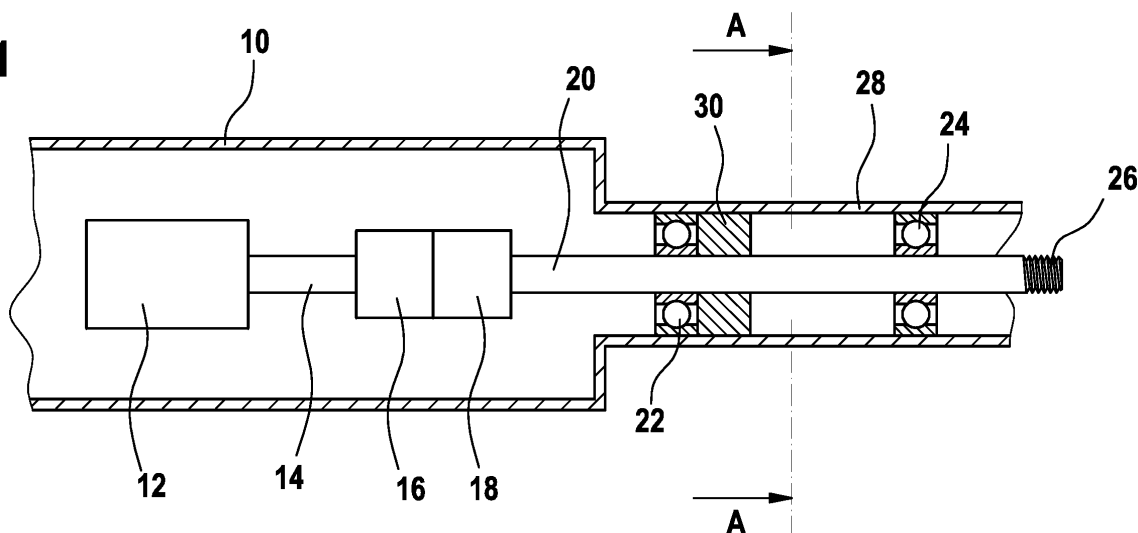
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(54) **Noise elimination brake for automatic spindle locking mechanism**

(57) A rotary power tool comprising a motor, a motor shaft driven by the motor, an output shaft coupled to the motor shaft via an automatic spindle locking mechanism,

a housing portion surrounding the output shaft, and a braking member that is non-rotatable relative to the housing portion, wherein the braking member exercises a braking torque on the output shaft whenever it rotates.

Fig. 1



Description

PRIOR ART

[0001] The present invention relates to rotary power tools and in particular those tools which are configured with an automatic spindle locking mechanism (ASLM). When the motor is inactive, an ASLM blocks a rotary tool output shaft from rotating in response to an external applied torque, for example resulting from rotation of a tool-holding chuck coupled to the output shaft. Through the years many different coupling arrangements have been employed, but usually the structure is such that rotation of the motor shaft will drive the output shaft, but rotation of the output shaft will not drive the motor shaft, and instead leads to engagement of the ASLM.

[0002] The motor shaft and output shaft of a power tool with an ASLM are typically coupled but with some rotational play remaining between the coupling parts. An undesirable consequence of this ASLM configuration arises when the motor shaft slows after the motor has been shut off. Due to its inertia, the output shaft tends to overtake the slowing motor shaft. Relatively speaking, an output shaft that is rotating faster than the motor shaft is in effect attempting to drive the motor shaft, and this leads to engagement of the ASLM. The locking action triggers a reactive force which slows the output shaft and disengages the ASLM. However the motor shaft continues to slow down more rapidly until its speed is once again less than the output shaft, and the process repeats. Repeated engagements, disengagements, and reengagements generate an undesirable chattering noise.

[0003] U.S. Patent No. 6,311,787 describes several means for counteracting this phenomenon, including an automatic brake and an automatic drag system. These are mediated by output shaft-coupled members which make frictional contact either with housing-coupled members or with motor shaft-coupled members, respectively. In both cases, this serves to slow the rotation of the output shaft relative to the motor shaft so that the frequency of chattering noise is reduced or eliminated altogether.

ADVANTAGES OF THE INVENTION

[0004] A disadvantage of the prior art solution is that the described structures comprise integral aspects of the design, and they cannot be readily incorporated into an existing rotary power tool without requiring an extensive redesign. What is needed is a simpler and less expensive means of achieving a similar outcome, and particularly a solution that can be implemented on an existing rotary power tool design, thereby requiring no redesign of the power train. It is also advantageous if the invention provides for an intuitive and predictable adjustment, so that the process of optimizing the solution for a particular rotary power tool is simplified.

[0005] These advantages are realized by providing a rotary power tool comprising a motor, a motor shaft driven

by the motor, an output shaft coupled to the motor shaft via an ASLM, a housing portion surrounding the output shaft, and a braking member that is non-rotatable relative to the housing portion, wherein the braking member exercises a braking torque on the output shaft whenever it rotates. This invention can be conveniently retrofitted to existing rotary power tools without requiring a detailed redesign.

[0006] If the output shaft is stabilized by at least two bearing members, a preferred and advantageous place for incorporating the braking member is in a position between the two bearing members, since this provides greater consistency to the amount of braking torque exercised by the braking member on the output shaft.

[0007] For ease of assembly, it is advantageous if the braking member is ring-shaped, thereby allowing the output shaft to position it radially. This shape is also preferable for ensuring consistent and uniform contact with the output shaft and the housing portion via its inner ring surface and outer ring surface, respectively.

[0008] It is advantageous if the braking member is in direct contact with the housing portion to provide means for immobilizing the braking member relative to the rotating output shaft. This contact is advantageously accomplished via an interference fit (i.e., a friction fit), since this requires no additional coupling parts, provides some flexibility and tolerance during assembly and minimizes assembly and material costs.

[0009] It is advantageous if the braking torque exercised by the braking member is of sufficient magnitude so that in the absence of an external torque urging the output shaft to rotate, the rotating velocity of the output shaft is always less than or equal to the rotating velocity of the motor shaft. When this is the case, all chattering noise created by the ASLM is eliminated.

[0010] It is advantageous when optimizing the design to pursue a braking torque that is neither too small nor too great to achieve the correct balance between removing the chattering noise without dissipating too much power. A predictable way of optimizing the forces of friction and adhesion is by adjusting the width of the inner surface of the braking member independently of the overall width by providing this inner surface with a chamfer-shape.

[0011] An additional way that the braking member can be kept in non-rotational contact with the housing portion is by providing the outer surface of the braking member with a structure that is complimentary with an inner surface of the housing portion.

[0012] So that the braking member can be easily fitted to the housing by an interference fit and not require additional members to stabilize the braking member against rotation, the braking member is advantageously composed of a flexible, non-metal material, such as felt, plastic, rubber or foam. In comparison with metals, these materials may have lesser material and manufacturing costs.

DRAWINGS

[0013]

Figure 1 is a schematic section view of a portion of a rotary tool according to the present invention.

Figure 2 is a partial schematic section view taken along section line A-A of Fig. 1.

Figure 3 is a perspective view of a braking member according to a first embodiment of the invention.

Figure 4 is a perspective view of a braking member according to a second embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] A portion of a rotary power tool and particularly a drill/driver according to the present invention is illustrated in schematic form in Fig. 1. The power source for such tools is typically either AC current or a DC battery. Positioned within the housing 10 of the rotary power tool are a motor 12 driven by this power source and its associated motor shaft 14. As is typical, a transmission 16 modulates the speed and torque conveyed by the motor shaft 14 to downstream elements in the power train.

[0015] An automatic shaft locking mechanism (ASLM) 18 is positioned downstream of the transmission 16. ASLM's are well known in the art, and the details of how they operate will not be described in detail in the present description. For examples of different ASLM's, readers are referred instead to U.S. Patent No. 6,311,787 and U.S. Patent Publication No. 2006/0131043 A1 which are hereby incorporated by reference. As is typical in the art, the transmission 16 may not necessarily be discrete from the ASLM 18. That is, there may be components that function as both part of the transmission 16 and the ASLM 18. Downstream from the ASLM 18 is an output shaft 20. The output shaft 20 may interact directly with the ASLM 18 or it may be coupled to one or more other elements in between.

[0016] A housing portion 28 comprises the portion of housing 10 that is coaxial with and surrounds the output shaft 20. The output shaft 20 is coupled with this housing portion 28 via two ring-shaped ball bearings 22 and 24 which serve to stabilize the shaft. At the end of the output shaft 20 is an output interface 26 for attaching a tool holder such as a drill chuck or the like. Alternatively tools can be attached directly to the output shaft 20 itself.

[0017] A braking member comprising a felt ring 30 is positioned between the two ball bearings 22 and 24. It surrounds the output shaft 20 and preferably is secured by an interference (friction) fit with housing portion 28. The resulting friction between the felt ring 30 and the housing portion 28 is much greater than the friction between it and the output shaft 20. As a result, the braking member will not rotate relative to the housing portion 28 when the output shaft 20 is rotating at typical operating speeds in the range of 400-1400 RPM. The friction can be of sufficient magnitude so that no means for maintain-

ing the position of the braking member in the axial direction are necessary. However, even if the braking member were free to move axially, the bearings 22 and 24 would serve to confine the braking member to the generally appropriate axial location around the output shaft 20, which is preferably at any axial point that is between the two bearings. Any friction resulting from contact of the braking member with the side of the ring-shaped ball bearing 22 is negligible in comparison to the frictional force exerted on the output shaft 20.

[0018] It is preferred that the braking member is positioned in the space between the bearings 22 and 24, but it may alternatively be positioned outside of them provided there is sufficient axial space to accommodate the braking member and there is no interference with other structures.

[0019] The felt ring 30 is seen in isolation in Fig. 3 and is characterized by an inner diameter 32, an outer diameter 34, and a thickness 36. The inner diameter 32 and the outer diameter 34 are chosen so as to satisfy the preferred frictional conditions discussed above. However, particular care has been taken to adjust the inner diameter 34 so as to control the frictional force between the inner surface 38 of the felt ring 30 and the output shaft 20. In a preferred scenario, this braking torque is just exactly enough so that the down-coasting velocity of the output shaft 20 is slowed to a rate exactly equal to that of the motor shaft 14. When this condition is satisfied, there is no engagement of the ASLM 18 when the power is cut to the motor.

[0020] However, this preferred scenario does not define the preferred embodiment, since with repeated use of the tool, there is wear on the felt ring 30, and this may alter the amount of friction between the braking member and the output shaft 20. In our tests, we find that the frictional force decreases with repeated use. Therefore the preferred embodiment has just enough friction to compensate for anticipated decreases in friction due to wear over the lifetime of the tool. In our tests, it appears that the frictional force decreases approximately 20 to 45% over the tool lifetime.

[0021] Though not described explicitly above, it is understood that too much friction between the braking member and the output shaft 20 is undesirable. As is well known, friction causes power to be dissipated as heat without providing mechanical advantage. As such it is desirable to minimize the frictional force. Also, while a secure friction fit is desirable, too great an outer diameter 34 makes it more difficult to assemble the housing halves that comprise the housing portion 28 surrounding the braking member.

[0022] Even a bearing that is designed to minimize friction will exert some frictional force on a shaft that it is supporting, thereby exerting a theoretical braking torque on the shaft. The braking member described here is not intended to provide support for the output shaft 20. It is intended to be of inexpensive construction, and is designed not for minimizing friction, but for introducing fric-

tion. The amount of braking torque it exerts is preferably adjustable and the alternative embodiment described below provides one manner of achieving precision in controlling this parameter during design of the tool.

[0023] A second embodiment for a braking member, comprising an elastic ring 40 made of soft resilient material is shown in isolation in Fig. 4. The elastic material may be a rubber, such as nitrile butadiene rubber (NBR), a plastic, such as acetal polyoxymethelene (POM), or a cellular urethane foam, such as Poron® (a registered U.S. trademark of Rogers Corporation), each of which could have the appropriate combination of elasticity and strength to serve as the braking member.

[0024] Note that the outer surface 41 of the elastic ring 40 is configured to have what can be generally characterized as protrusions 42 and recesses 44. In this case, these features are intended to cooperate with complementary recesses 46 and protrusions 48 respectively that may be present on the inner surface 49 of the housing portion 28 (see Fig. 2). Such cooperation would potentially lessen the extent to which a friction fit between the elastic ring 40 and the housing portion 28 is necessary.

[0025] Alternative means for securing the braking member against rotation include configuring the housing portion 28 with pin-like structures (not shown) that would puncture and deeply penetrate the braking member during the housing assembly process. Alternatively, even if the housing portion 28 is configured with recesses 46 and protrusions 48, a braking member without cooperating features can be used (see Fig. 3) since the braking member is composed of compliant material. In any case, through whatever means, it is preferred that the braking member does not rotate during operation of the rotary tool, since this results in wear on the braking member and housing portion 28, heat generation, and adds variability to the system, so that it may be more difficult to make predictions when optimizing the braking member dimensional parameters.

[0026] Protrusions and recesses could also be provided on the felt ring 30. However this may be more complicated or costly from a manufacturing standpoint versus an elastic ring 40 which can be made from a variety of materials that lend themselves well to injection molding. Hence when more complicated surface contours are desired, the braking member is preferably manufactured from moldable materials.

[0027] Changing the contact area with the output shaft 20 by varying the inner surface 50 of elastic ring 40 is one way to optimize the amount of braking provided by the brake member. The inner surface 50 of the elastic member 40 can be chamfered to create a chamfered surface 52. Alternatively such a surface, though only appearing to be chamfered, can be achieved through injection molding. This rather simple constructional manipulation allows one to make predictions in adjusting the braking torque since the forces of friction and/or adhesion appear to be related to the contact area between the braking member and the output shaft 20.

Claims

1. A rotary power tool comprising:

a motor (12);
a motor shaft (14) driven by the motor (12);
an output shaft (20) coupled to the motor shaft (14) via an automatic spindle locking mechanism (18);
a housing portion (28) surrounding the output shaft (20); and
a braking member (30, 40) that is non-rotatable relative to the housing portion (28); **characterized in that** the braking member (30, 40) exercises a braking torque on the output shaft (20) whenever it rotates.

2. A rotary power tool according to claim 1, **characterized in that** the output shaft (20) is stabilized by at least two bearing members (22, 24) and the braking member (30, 40) is positioned between the at least two bearing members (22, 24).

3. A rotary power tool according to any one of the preceding claims, **characterized in that** the braking member (30, 40) is ring-shaped and contacts the output shaft (20) along its inner surface (38, 50).

4. A rotary power tool according to any one of the preceding claims, **characterized in that** the braking member (30, 40) is in direct contact with the housing portion (28).

5. A rotary power tool according to any one of the preceding claims, **characterized in that** the braking member (30, 40) and the housing portion (28) are coupled by an interference fit.

6. A rotary power tool according to any one of the preceding claims, **characterized in that** an inner surface (50) of the braking member has a chamfer-shaped surface (52).

7. A rotary power tool according to any one of the preceding claims, **characterized in that** an outer surface (41) of the braking member (30, 40) has a structure complimentary with an inner surface (49) of the housing portion (28).

8. A rotary power tool according to any one of the preceding claims, **characterized in that** the braking torque is of sufficient magnitude so that in the absence of an external torque urging the output shaft (20) to rotate, the rotating velocity of the output shaft (20) is always less than or equal to the rotating velocity of the motor shaft (14).

9. A rotary power tool according to any one of the pre-

ceding claims, **characterized in that** the braking member (30, 40) is made of a flexible non-metal material.

10. A rotary power tool according to any one of the preceding claims, **characterized in that** the braking member (30) is composed of felt. 5
11. A rotary power tool according to any one of claims 1 through 9, **characterized in that** the braking member (40) is composed of plastic, rubber or foam. 10

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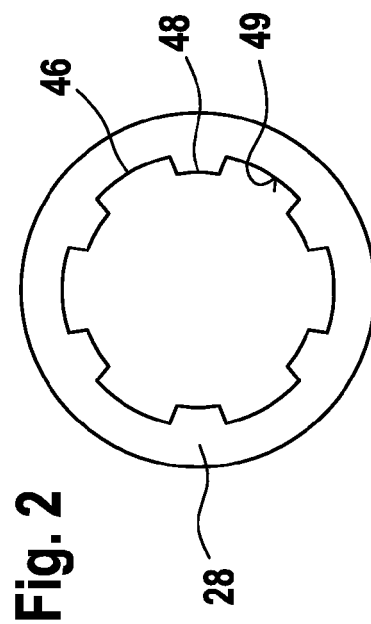
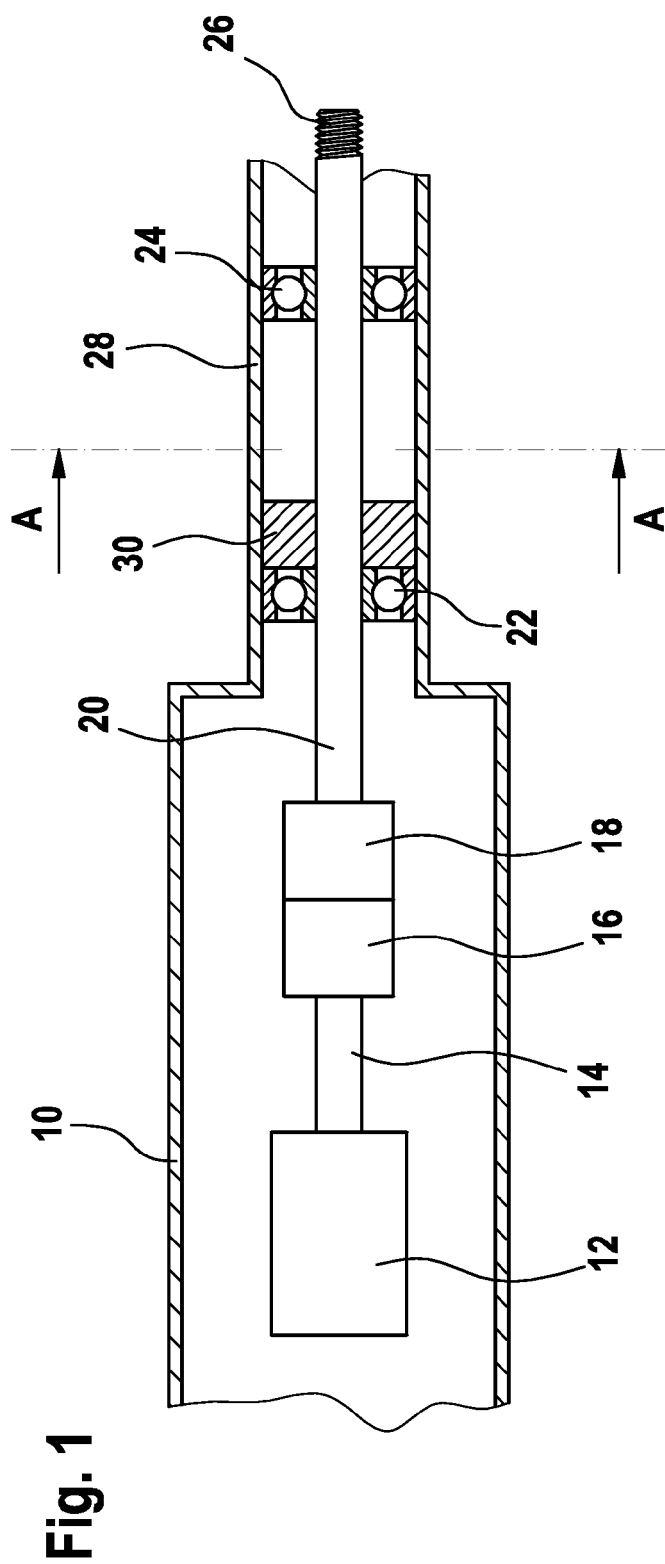
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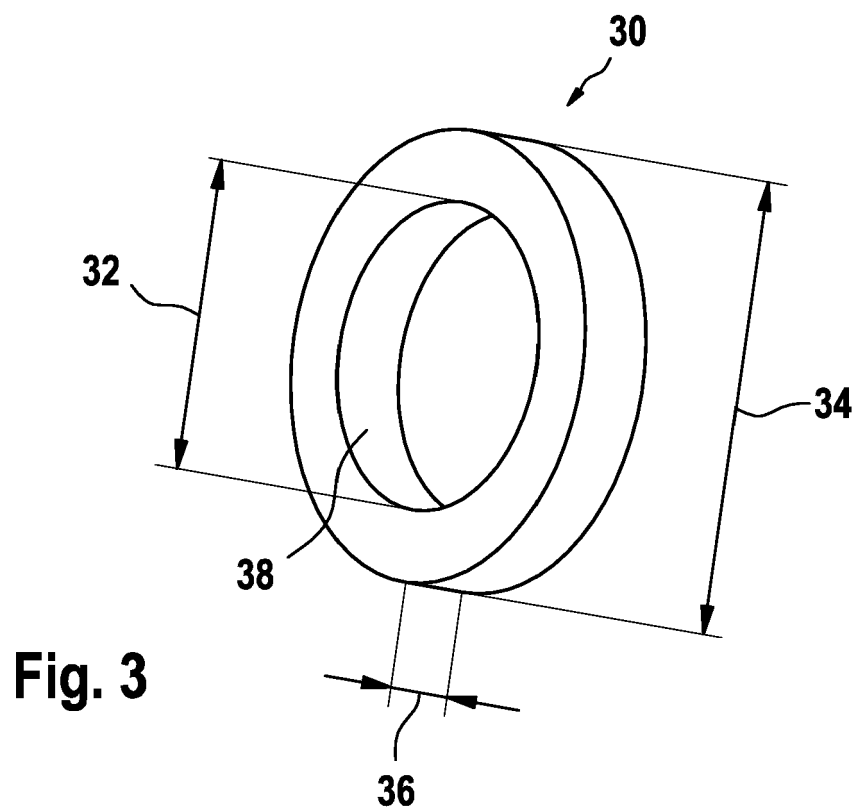


Fig. 3

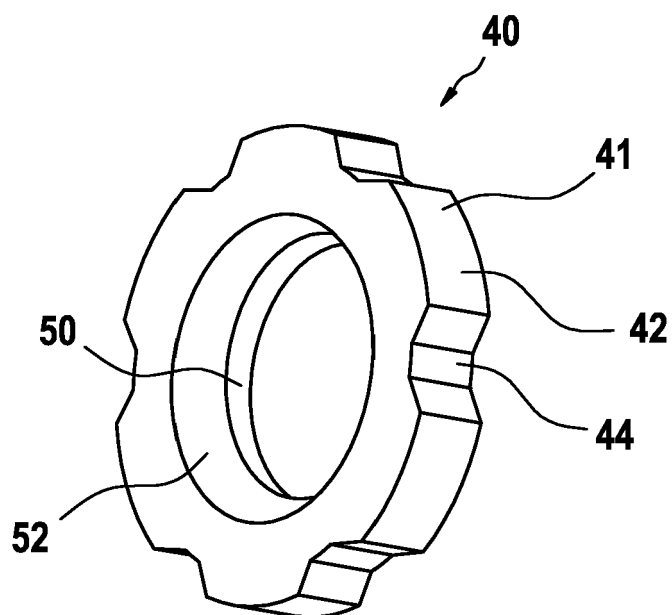


Fig. 4



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 11 1436

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Place of search The Hague		Date of completion of the search 7 December 2007	Examiner Garella, Mario
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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